EMU CMS Meeting

Draft

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CSC gas system specifications

- Gas mixture, gas component specs
- Detector volume
- Chamber layout connections on disks
- Individual gas lines and rates
- Global view on gas flow, recycling, leaks, air intake, purification, recuperation
- Pipes, cleaning, outgasing
- Gas pressure analysis
- Controls/Safety for different operation conditions
- Conclusion

Gas mixture, gas component specificatior

40%Ar + 50%CO_2 + 10%CF_4

- **mixing precision: ±1% or better**
- **stability over one year: ±0.3% or better**
- **fresh gas component specs (CERN Catalog)**
  - **Argon 46 (99.996% purity)**
  - **Carbon Dioxide 40 (99.99% purity)**
  - **CF_4 45 (99.995% purity)**
- **reserve room for a fourth gas component (e.g., H_2O, iso-C_4H_{10})**

Cost Estimation

(conversion $1 = 1.5 CHF)

Gas Components	Gas Component Cost		Gas Mixture Cost	Gas Mixtu Cost
	CHF/kg	CHF/m3	CHF/m3	USD/m3
Argon 46	2.2	3.92	1.57	1.05
Carbon Dioxide 40	13.17	5.57	2.79	1.86
Tetrafluoramethane 45	78.25	285.6	28.56	19.04
		Total:	32.91	21.94

Fresh gas component specs CERN Store Catalog

.A: ARGON 46 - Ar

tion:
CHNICAL SHEET : LO-GE N° 230
NIMUM PURITY : 99.996%
XIMUM IMPURITIES :
: 5 ppm : H2O: 10 ppm
t classified as a hazardous substance
EMICAL FORMULA : Ar
LABEL : 9.23
OLAR MASS : 39.948 g/mol
LUME MASS : 1.78 kg/m3
ILING POINT : -185.86°C
STINCTIVE COLOUR : brown-green
LINDER PRESSURE : 200 bar at 15°C
LINDER UNION : W21, 8x1/4" r.h.

0.140.8: ARGON 46 - 10,6 M3
Code: 60.02.10.140.8
ption: ARGON 46 - 10,6 M3

ce: 3.92 CHF for 1 CUBIC METRE
t of Issue: 1 BOTTLE(S) of 10.6 CUBIC METRE
ailable Self Service: No
nual Forecast: 475 CUBIC METRE

racteristics:
NDITIONNEMENT: bouteille de 50 litres

60.04.15.D: CARBON DIOXIDE 40 - CO2

Description:
MAC VALUE : 5000 ppm
CHEMICAL FORMULA : CO2
MOLAR MASS : 44.010 g/mol
VOLUME MASS : 1.98 kg/m3
SUBLIMATION TEMP. : -78.5°C
DISTINCTIVE COLOUR : dust grey RAL 7037
BOTTLE UNION : W21.8 x 1/14" r.h.
PURITY : >99.99%
IMPURITIES : O2 < 20 ppm H2O < 30 ppm
CO+CnHm < 20 ppm

60.04.15.225.2: CO2.40 BK 12 CYL. - 450 KG
Item Code: 60.04.15.225.2
Description: CO2.40 BK 12 CYL. - 450 KG

Price: 5.57 CHF for 1 KILOGRAM(S)
Unit of Issue: 1 BANK(S) of 450 KILOGRAM(S)
Available Self Service: No
Annual Forecast: 180 KILOGRAM(S)

Characteristics:
GAZ: CO2 40
PRESSION bt. (15 °C): 49,5 bar
CONDITIONNEMENT: batterie de 12 bouteilles

60.56.10.C: TETRAFLUOROMETHANE 45 - CF4

Description:
TECHNICAL SHEET : N° 511
MIN. PURITY : 99.995%
MAX. IMPURITIES : H2O: 5 ppm CO: 5 pp
CO2: 5 ppm O2: 5 ppm
N: 20 ppm Others: 10 ppm
VOLUME MASS : 3.65 kg/m3
CYLINDER UNION : W21,8 x 1/14" r.h.

60.56.10.100.7: TETRAFLUOROMETHANE 45 -
Item Code: 60.56.10.100.7
Description: TETRAFLUOROMETHANE 45 - 3

Price: 78.25 CHF for 1 KILOGRAM(S)
Unit of Issue: 1 BOTTLE(S) of 32 KILOGRA
Available Self Service: No
Annual Forecast: 8 KILOGRAM(S)

Characteristics:
CONDITIONNEMENT: bouteille de 50 litres

Chemical Compatibility

http://www.praxair.com/Praxair.nsf/X1/specga_purega?openDocum

y to Materials Compatibility

Satisfactory for use with the intended gas.

Unsatisfactory for use with the intended gas.

hru C7 - Conditionally acceptable for use with the intended gas as follows:

Satisfactory with brass having a low (65-70% maximum) copper content. Brass with higher copper content is unacceptable.

Satisfactory with acetylene; however, cylinder acetylene is packaged dissolved in a solvent (generally acetone) which may be incompatible with these elastomers.

Compatibility varies depending on specific Kalrez® compound used. Consult E. I. DuPont for information on specific applications.

C4-Satisfactory with brass, except where acetylene or acetylides are present.

C5-Generally unsatisfactory, except where specific use conditions have proven acceptable.

C6-Satisfactory below 1000 psig.

C7-Satisfactory below 1000 psig where gas velocities do not exceed 30 ft /sec.

I - Insufficient data available to determine compatibility with the intended gas.

Compatibility Chart

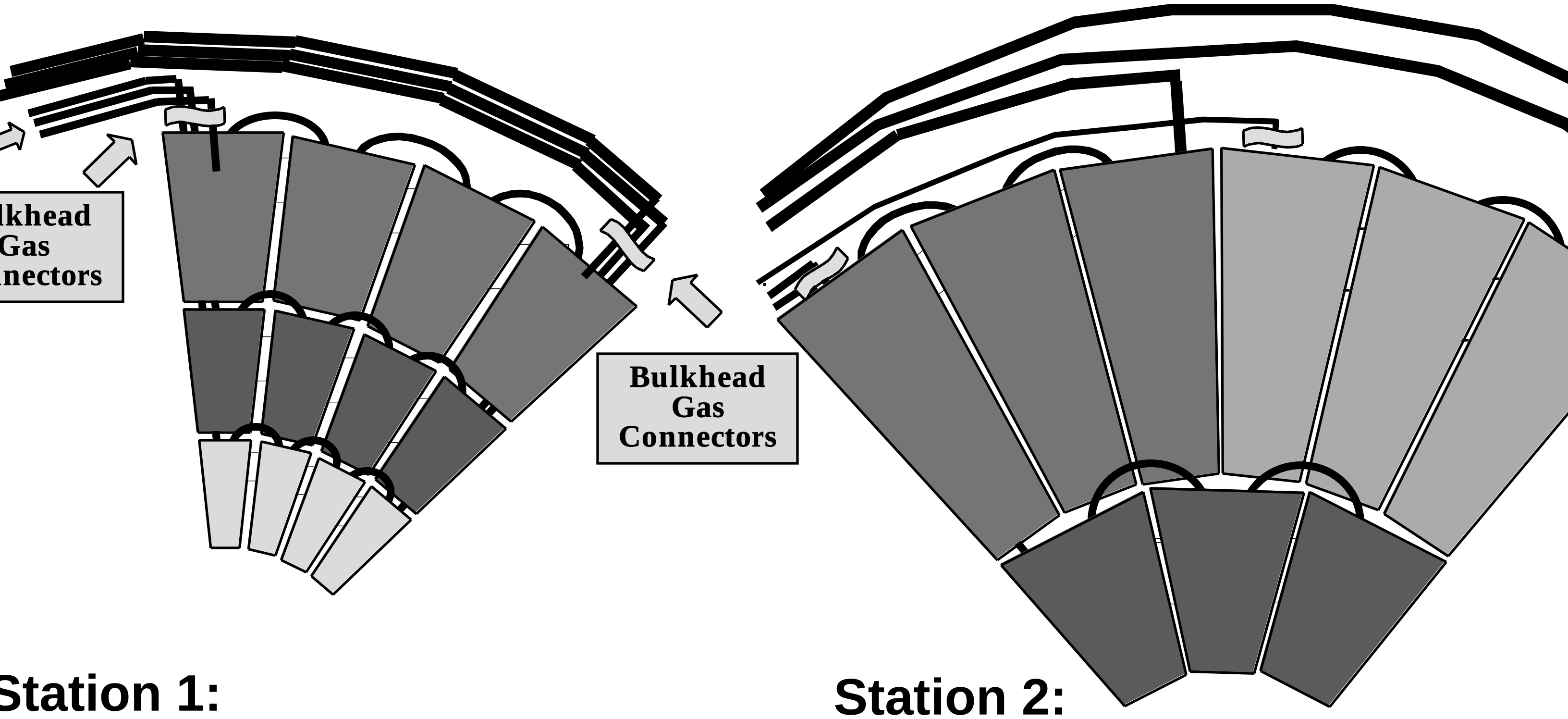
		Materials of Construction															
		Metals							Plastics						Elastome		
Common Name	Chemical Formula	Brass	Carbon Steel	Stainless Steel	Aluminum	Zinc	Copper	Monel	Kel-F	Teflon	Tefzel	Kynar	PVC	Polycarbonate	Kalrez	Viton	Buna-N
Carbon Dioxide	CO_2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Argon	Ar	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Halocarbon 14	CF_4	S	S	S	S	I	S	S	S	S	S	S	U	U	C3	S	S

Detector Volume

Chamber Type	Quantity	Chamber Volume (liter)	Sub-Total Volume (liter)
ME 1/1	72	28	2016
ME 1/2	72	75	5400
ME 1/3	72	81	5832
ME 2/1	36	106	3816
ME2/2	72	193	13896
ME 3/1	36	99	3564
ME3/2	72	193	13896
ME 4/1	36	91	3276
ME 4/2	72	193	13896
		Total:	**65592**

Detector Volume without ME4/2 = 51.7 m^3

Chamber Layout Connection on Disk



Station 1:

- Four ME1/1 per gas line
- Four ME1/2 per gas line
- Four ME1/3 per gas line

Station 2:

- Three ME2/2 per gas line
- Three ME2/1 per gas line

Stations 3 and 4: similarly

Gas and Water pipeline layout must be the same

Gas Flow Lines and Rates

Gas lines and gas flow rates per one Endcap

Disk	Module	Chambers	Single	CSCs	Volume	Volume	Nominal	No. of	
		in ME z/r	Chamber	per	per	exchange	Channel	Gas	F
		Ring	Volume	gas channel	gas channel		Flow rate	Channels	
			(liter)		(liter)	(hours)	(liter/hour)		(
1	ME1/1	36	28	4	112	6	19	9	
	ME1/2	36	75	4	300	6	50	9	
	ME1/3	36	81	4	324	12	27	9	
2	ME2/1	18	106	3	318	6	53	6	
	ME2/2	36	193	3	579	12	48	12	
3	ME3/1	18	99	3	297	6	50	6	
	ME3/2	36	193	3	579	12	48	12	
4	ME4/1	18	91	3	273	6	46	6	
	ME4/2	36	193	3	579	12	48	12	
Total per Endcap:		270						81	

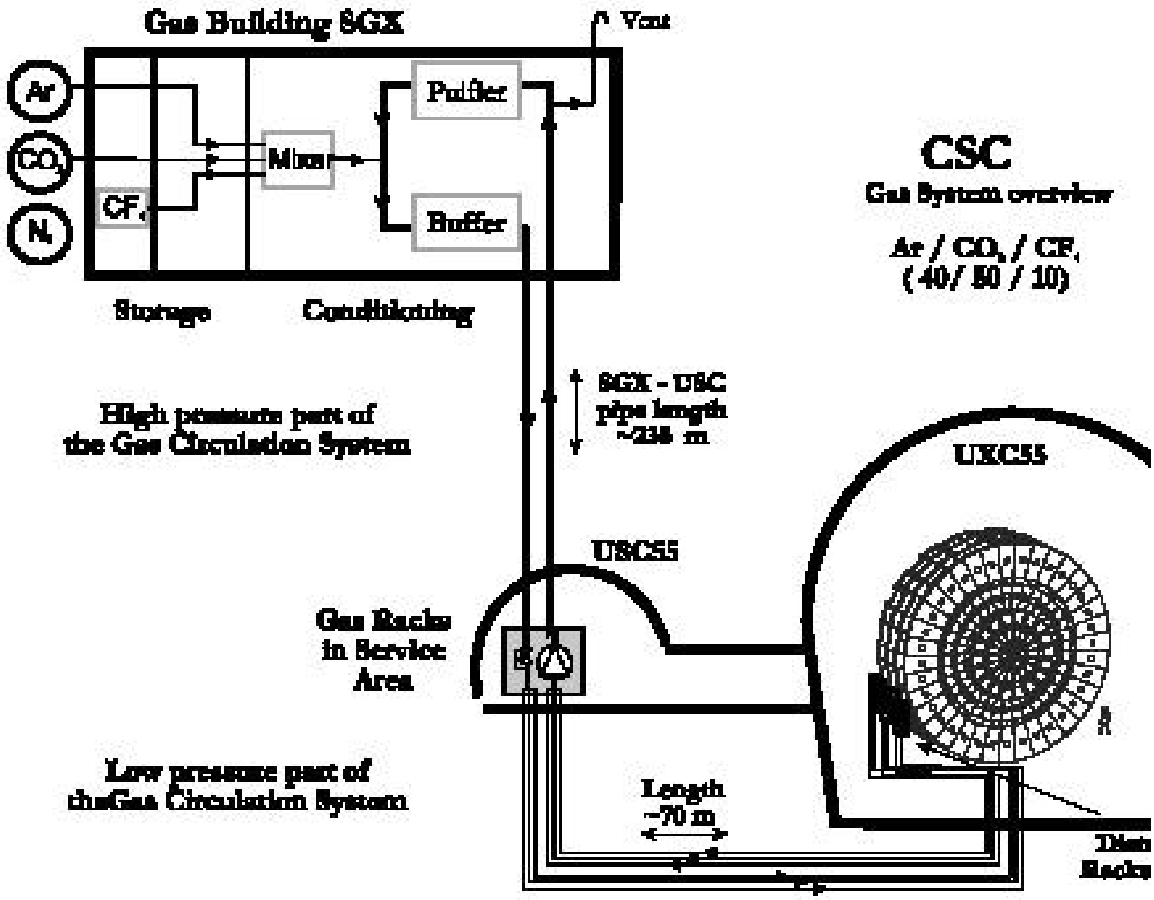
e Gas Channel (3 or 4 CSCs): 1 Volume exchange in 6-12 hours

e CSC: 1 Volume replacement in 1.5-4 hours

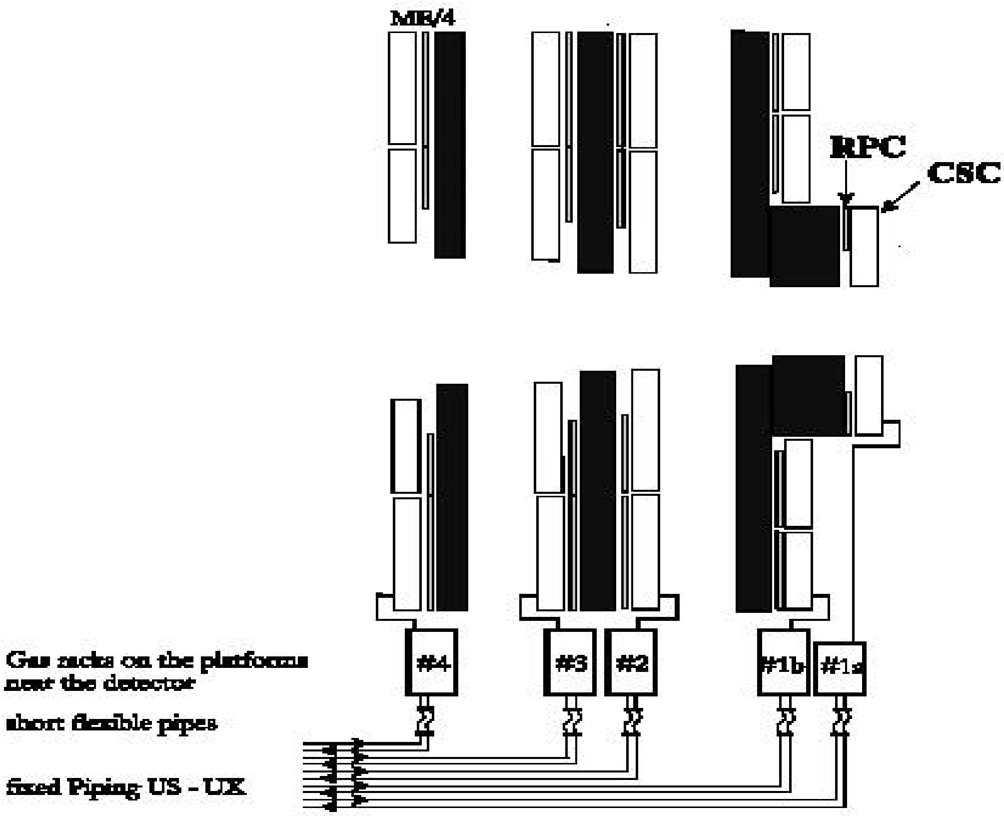
al EMU: 7 m^3/hr (nominal);

126 (~50 l/hr) + 36 (~25 l/hr) = 162 gas lines

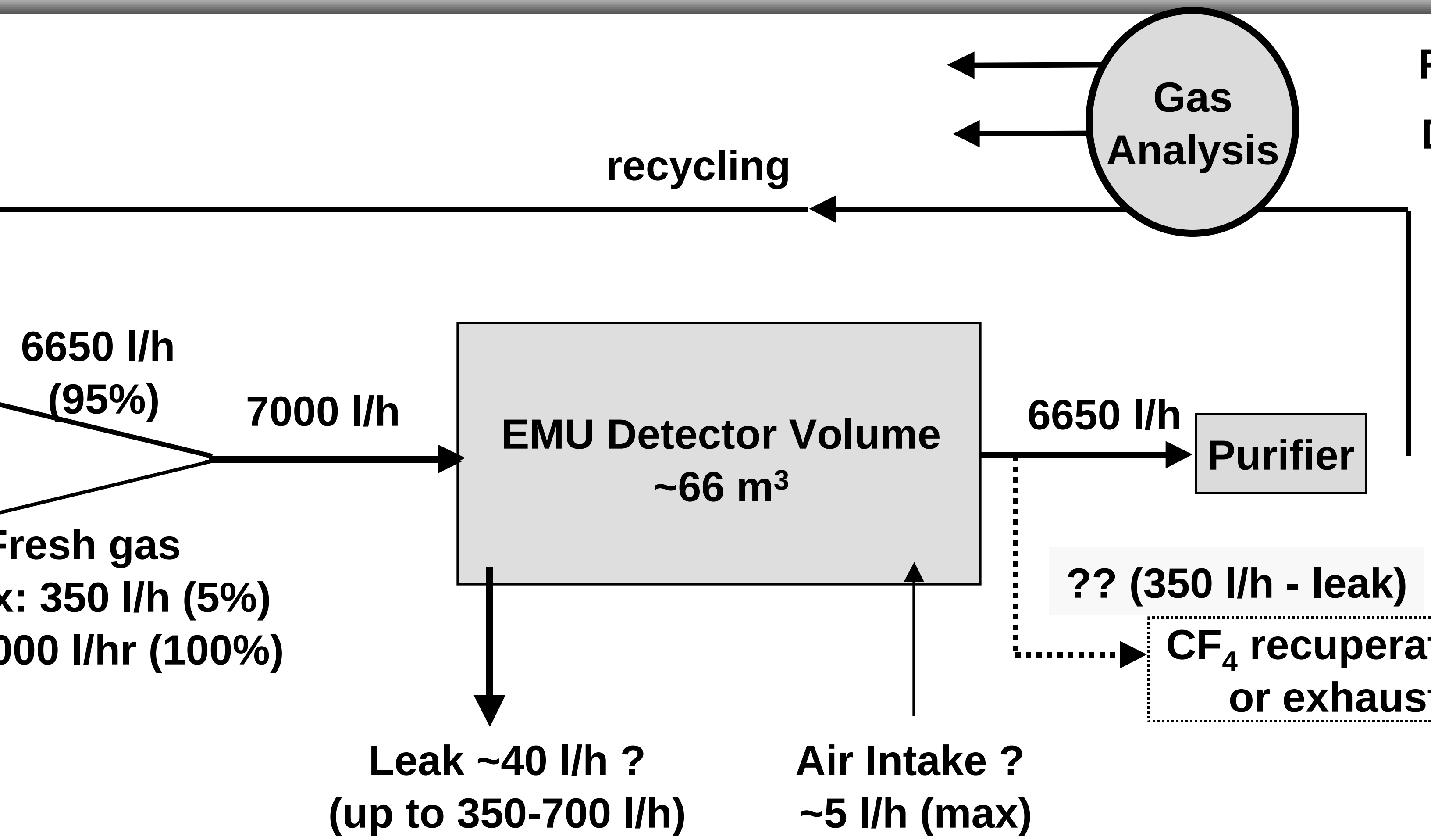
CSC Gas System



Gas Rack Layout



Gas Flow Global View



Gas Flow Meters

Individual Gas Lines:

- **inlets: 36 lines at 25 l/hr and 126 lines at 50 l/hr**
- **outlets: 36 lines at 25 l/hr and 126 lines at 50 l/hr**

Fresh Gas Injection Line (two set of mass flow controllers):

- **normal run: 350 l/hr**
- **fill in: 7000 l/hr**

Recycling:

- **collection: 7000 l/hr**
- **return to detector: 7000 l/hr**

Exhaust (or CF_4 Recuperation)

- **350 l/hr ???**

All numbers are for nominal flow (50% of max)

EMU Gas Leaks

Chamber Leaks:

- **production test $<10^{-5}$ CSC volumes per min (at 1 mbar):**
  - **<2 cc/min for large CSCs**
  - **<1 cc/min for small CSCs**
  - **will change to 5 mbar…**
- **leak rate: we do not expect to exceed**
  - **$< 10^{-5} \times 60$ min/hr $\times 66$ m^3 = 40 l/hr**
  - **<u>however, one should be careful with extrapolations…</u>**
- **At leak of 700 l/hr (~20 times larger than expected):**
  - **we will exceed our ability to supply enough fresh gas (fixabl**
  - **we will be paying $100K/yr for gas (twice the estimated cost for the system without a CF4 recovery plant)**

CF4 Recovery

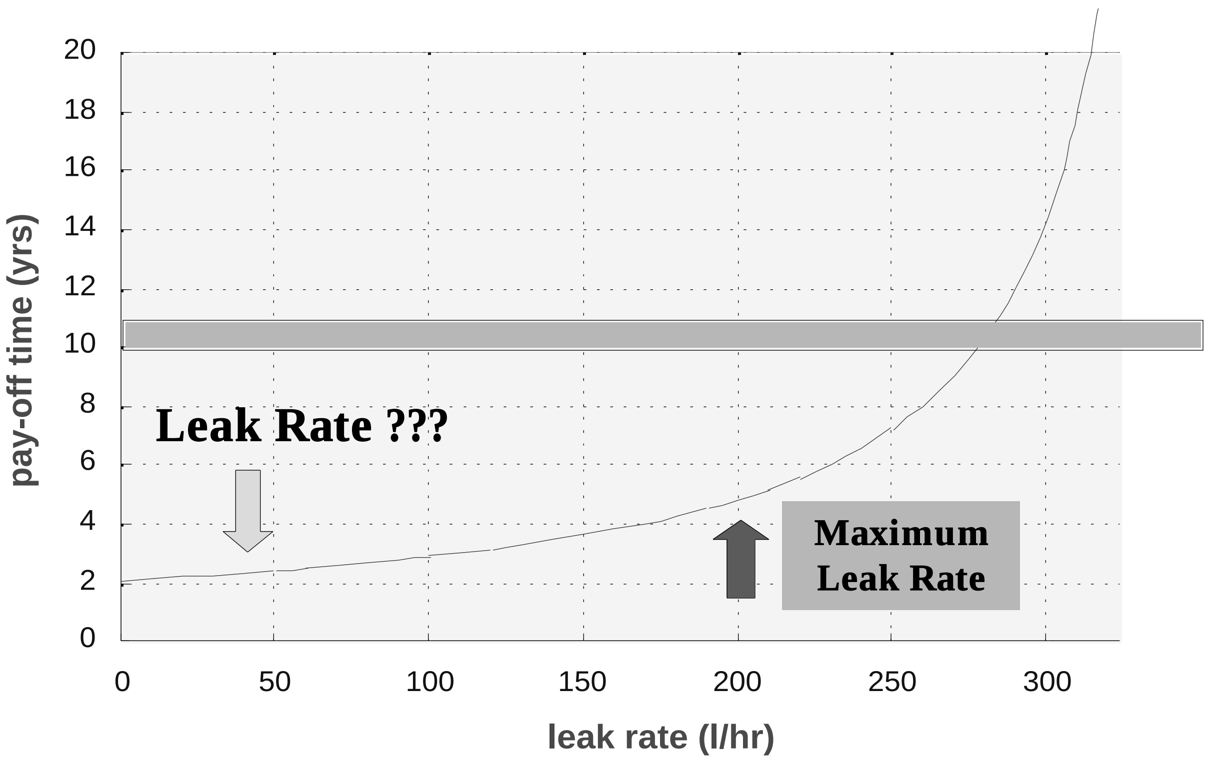
4 Recovery Factory: 100K CHF = $70K

s Expenses (no recovery): ~0.35 m^3 /hr x 24 h x 8 months x $22/m^3 = $45K/yr

suming 75% efficiency, the recovery will save: (350-leak)/350 x75% x$45K/yr

e recovery plant will pay off for itself in:

$70K / ((350-leak)/350 x 75% x $45K) yrs



Air Intake. Purification.

ata on air intake rate are available (measurements will be done)

irst measurements in Lab.7 were unsuccessful (RGA was broken

Worst Case Scenario:

- **1.5% of air (mostly N_2) results in noticeable change in performance**
- **350 l/hr (fresh gas) × 1.5% = 5 l/hr is max allowable**
- **Implications for O_2 and H_20 and Purification:**
  - 20% of O_2 in air: **1 l/hr of O_2, or 750 l/month**
  - 3% of H_2O at 100% humidity: **0.15 g/hr of H_2O, or 100 g/month**

ication Requirements:

100 ppm of O_2 (max removal rate 1 l/hr of O_2, or 750 l/month)

Capacity of the activated copper is about 45 g for 2 liter of O_2 => 17 kg

1000 ppm of H_2O (max removal rate 0.15 g/hr of H_2O, or 100 g/month)

N_2 (monitoring only, 3000 ppm for warning)

Outgasing and discharge products (oil, Si, SiF_4, SnF_x, ...)--TBD

On-Disk Pipes

Is this type OK?
39.71.05.B: ROUND TUBES - COPPER (

Description:

STANDARD: ISO 1635 - DIN 17671
ALLOY SYMBOL : Cu DHP
STATE : O (ANNEALED)
CHEMICAL COMPOSITION : Cu =
P = 0.013 - 0.050%
MECHANICAL CHARACTERISTICS
Elongation at break A5 : min. 38%
Vickers hardness VH 10 : 40 to 65
SEAMLESS DRAWN TUBES
MANUFACTURING LENGTH: 50 m

supply pipe running along disk perimeter:

- **ID/OD=10/12 mm, copper**
- **upstream connector to the gas rack (?)**
- **12mm/12 mm tube to tube bulkhead connector (?**

supply pipe to the 1st chamber

- **ID/OD=10/12 mm, (copper, flexible pipe?)**
- **upstream connector (?)**
- **downstream connector to match CSC connector:**
  12 mm copper tube x 1/4" male FNPT brass connector (PARKER P/N GBZ 12-1/4-B)

chamber-to-chamber pipes

- **ID/OD=10/12 mm, (copper, plastic?)**
- **upstream/downstream connectors to match CSC connectors**

last chamber to the return pipe

- **ID/OD=10/12 mm, (copper, plastic?)**
- **upstream connector to match CSC connector:**
- **upstream connector to match bulkhead connector of the return pipe(?)**

return pipe running along disk perimeter

- **ID/OD=14/16 mm, copper; connectors: ?, ?**

Pipe cleaning

Copper pipes to be cleaned (according to Ferdi Hahn):

- hydrochloric acid,
- soap washing (P17),
- demineralised water,
- alcohol,
- dry air,
- pumping?

Other elements and pipes to be cleaned:

- Valves
- ???

Any elements that may outgas (especially oil)?

- Pumps? Valves? Bubblers? Etc.

Overpressure in CSCs

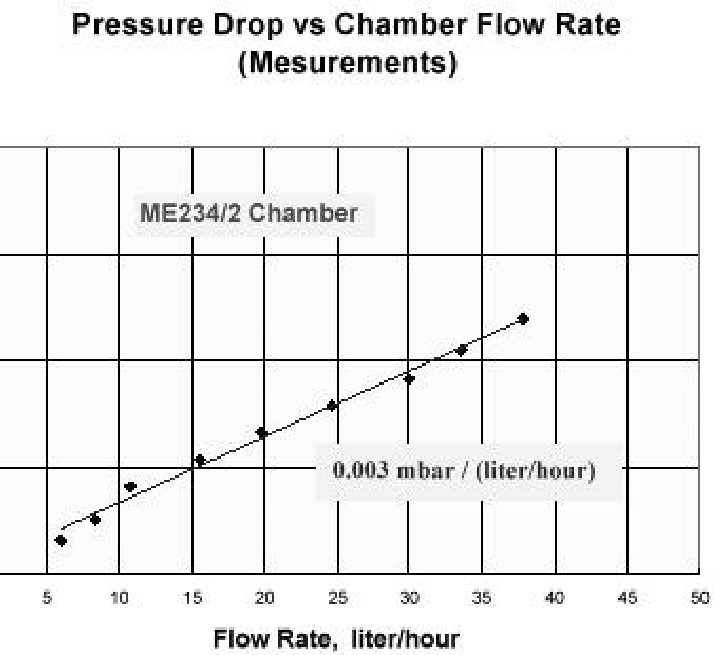
Chamber Pressure Operation Range:

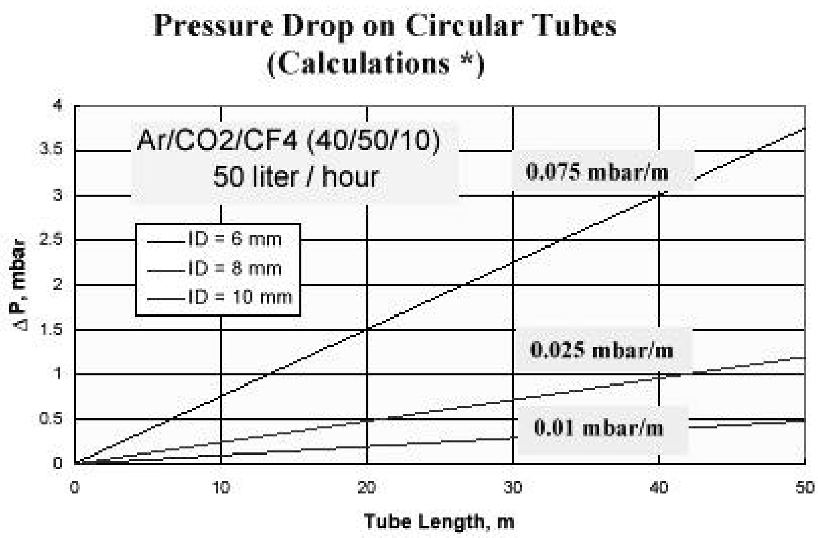
- CSC nominal pressure to be within 1 to 3 mbar
- Max pressure 5 mbar (bubbler relief to air, control actions)
- Low pressure 0.5 mbar (control actions)

Chamber pressure depends:

- **pressure drop in the chambers, pipelines**
- **hydrostatic pressure (chamber location on the disk)**

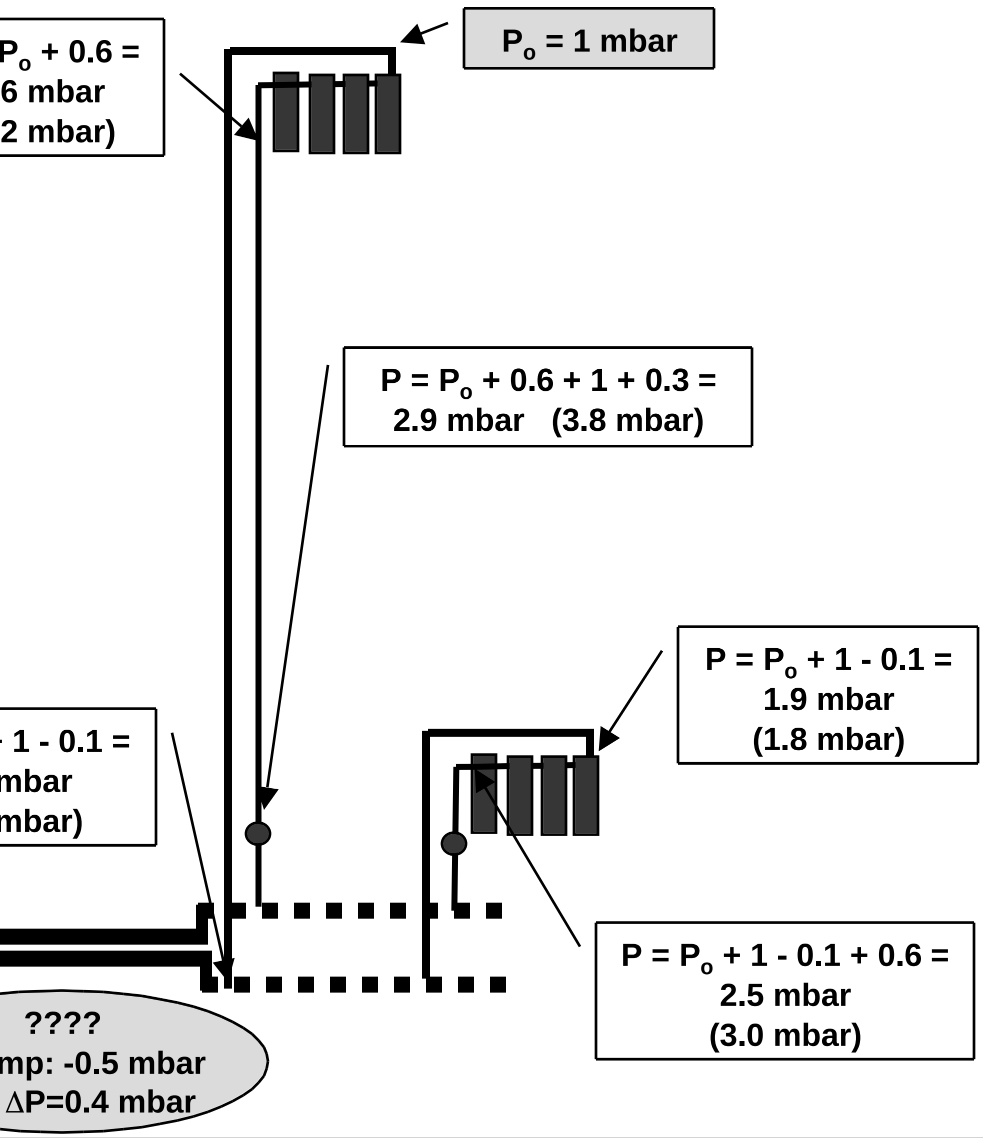
Pressure Drop





- CERN GWG: http://lhcexp.web.cern.ch/LHCExp/GasWG/standard/p_drop.htm

Simplified Overpressure Analysis



CSC:
Δp=0.15 mbar at 50 l/hr (measured),
0.6 mbar for 4 chambers

Pipe of 10 mm ID:
Δp=0.01 mbar/m at 50 l/hr (calcul.), 0.3 mba
30 m long pipe

Pipe of 14 mm ID:
Δp=0.003 mbar/m at 50 l/hr (calcul.), 0.1 mbar for 30
long pipe

Hydrostatic pressure :
Δp=0.071 mbar/m, 1 mbar fo
m

Chamber Overpressure: scheme of measurements

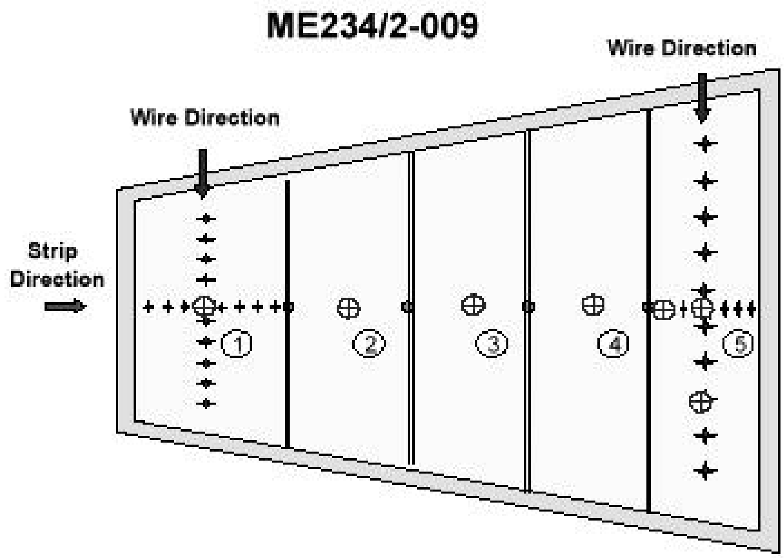
Scheme of Measurements

Pressure above atmospheric --> 0-10 mbar

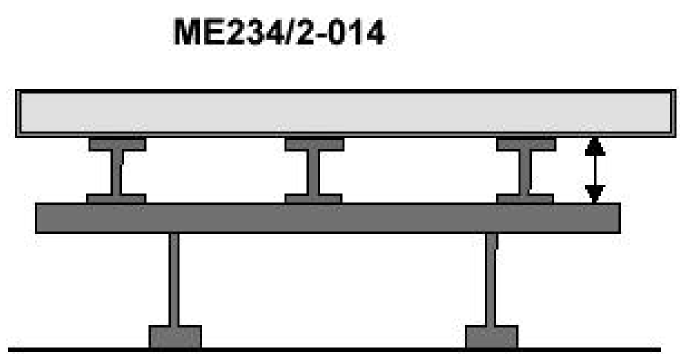
+ - points of measurements with CS-137

⊕ - points of panel deflection measurements

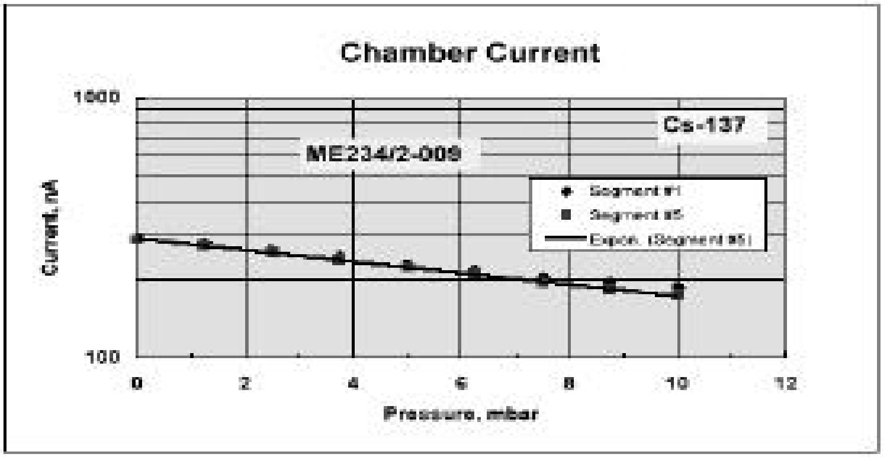
Chamber current measurements with CS-137



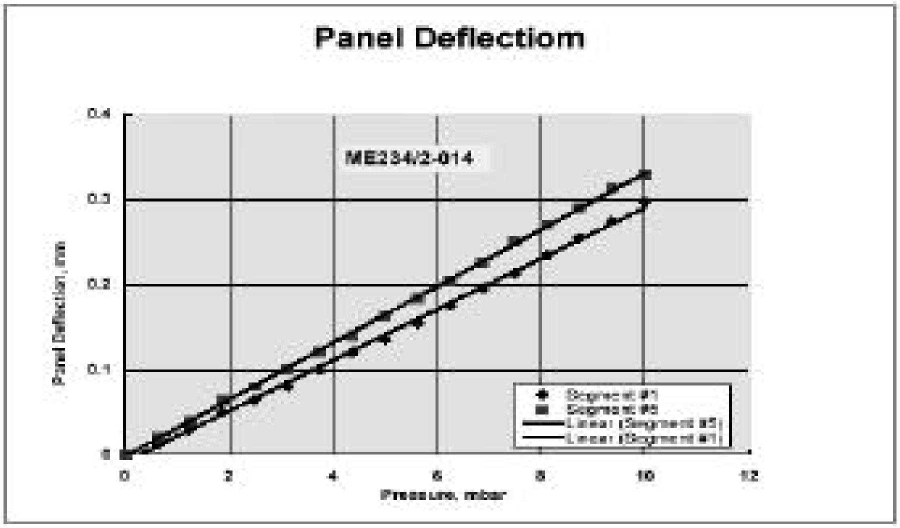
2. Chamber deflection measurements



Chamber Performance at Overpressure



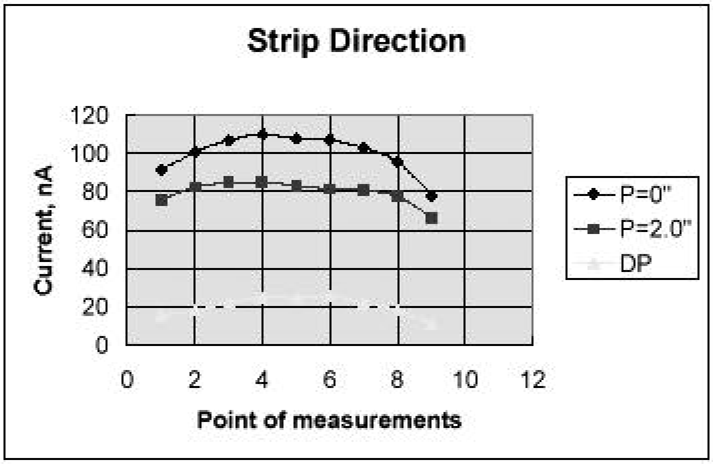
$\Delta A/A = 2\% / \text{mbar}$

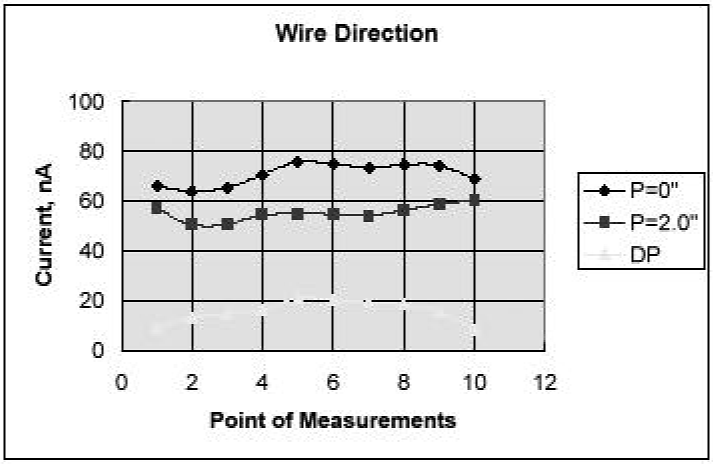


Panel deflection:

0.03 mm/mbar

Operation, Gas System Control





At ΔP = 5” water (5 mba

ΔA/A = 10%

Operation, Gas System Control

- Filling
- Normal Run
- Shutdown
- Opening disks or moving the whole endcap
- Standby with no gas flow
- Dismounting chambers; reinstalling chambers
- Alarms (wrong flow, pressure, gas, broken elements, leaks, purifier monitor) and corresponding actions
- Troubleshooting (leaks, broken elements, ???)
- Fool-proof analysis (control mistakes, abrupt weather changes, element failure)
- Impurities analysis
- Maintenance (flow meter and pressure sensor calibration, purifier maintenance, pneumatic valves, etc.)

Conclusion

As results of EMU gas system studies we defined:

- **Gas component specs**
- **Actual chamber volumes**
- **Chamber interconnection on the disk**
- **Chamber operational gas flow rates**
- **Pipeline material and diameters**
- **Chamber operational pressure range**
- **Leak rate and air intake limits**
- **Purification requirements**

till, there is a lot to do to finalize the specifications…

prototype of the closed loop gas system must be tested with a CSC nder intense radiation (ageing test at CERN)